Evaluating a Picture Archiving Communication System Workstation

Bradley J. Erickson

AN EFFICIENT environment for picture archiving communication system (PACS) in the radiology department and throughout a medical practice requires good hardware, good software, and integration of the information components that exist in a radiology department and hospital. This tutorial will describe some of the considerations in evaluating a soft-copy workstation, with a view to the hardware requirements, software interface designs, and integration with the archival and information systems.

WORKSTATION HARDWARE CONSIDERATIONS

The need for good hardware is obvious—you need to be able to display images quickly and the images must be displayed with good quality. Such measurements would seem to be fairly straightforward to provide and indeed are the easiest part of the PACS evaluation equation. The evaluation of the hardware of a PACS workstation include the actual computing unit, the monitor, and the network interface.

The cathode ray tube or computer monitor is the device which most significantly affects image display quality. The American College of Radiology has specified several measurements that it recommends for image interpretation, including spatial resolution (2.5 lp/mm), contrast resolution (8 bits/pixel), and brightness (>50 ft-L).[1]

There are several network technologies that are available; all serve to communicate information between computers. In some cases, the architecture of the PACS is built on the assumption that networks are not able to transmit images at the rate that the user would like to view them. Therefore, images are transferred to a workstation based on rules, with the expectation that they will be viewed at that location. In this case, the speed of the network is not important and instead the demand is placed on the local hard disk. An important assumption is that the place where images will be viewed can be predicted. At least one vendor uses a central store of images and has designed a network that can transfer images at an acceptable rate. The current product uses a proprietary fiber optic system that is unidirectional and therefore can achieve its theoretical signaling rate of 100 Mb/sec. The bottom line is that the demand on network is highly dependent on the architecture of the system and your ability to predict where images might be required.

SOFT-COPY INTERPRETATION TOOLS

Although viewing computed tomography (CT) and radiographic films may be similar in the light box arena, viewing the images soft copy seems to be substantially different. One important difference is that cross-sectional images can be three dimensional, which may provide additional information if viewed as a stack. CT images have presets for certain components of the image such as soft tissues, bones, or lungs. CTs and magnetic resonance images (MRIs) also have a smaller image matrix allowing many more images to be displayed for a certain number of pixels on the monitor. CTs and MRIs also have multiple series of images per examination, whereas radiographs usually have only a few images per examination.

For computed radiography there are six or seven "reading tools" that are considered to be important for diagnostic reading. These include the ability to easily rearrange images, adjust window width and level, magnify and zoom, flip and rotate, invert gray scale, measure distances, angles, and areas, and annotate the image. This contrasts with needs in cross-sectional to view images in stack, page, cine, and MPR formats, having presets for CT with automatic width and level calculations for MRI with the ability to adjust these widths and level values, measure pixel values, distances and areas, annotate and perhaps image flip and rotate.

For any soft copy reading package there should be a single image display metaphor (IDM). An IDM is the underlying concept of how the software designer expects the user to interact with images. It is clearly advantageous for the IDM to be easy to

From the Department of Radiology, Mayo Clinic, Rochester, MN.

Address reprint requests to Bradley J. Erickson, Department of Radiology, Mayo Clinic, 200 First St SW, Rochester, MN 55905.

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understand or remember and it should be generalizable/powerful. If it is, users can predict how to accomplish a function or arrangement that they had not been taught or cannot remember. In evaluating a PACS workstation you should try to determine what that metaphor is and decide whether or not the IDM is comprehensible, reasonable, consistently followed for all types of images, and whether that metaphor is powerful.

There are probably three generations of IDMs that have been used. The first generation was easy to understand but not very powerful because it basically allowed for one image on the screen. Adjusting width and level or a next or previous image applied to that one image.

In the second-generation IDM, windows debuted and so each window displayed an independent set of images. This allowed simultaneous display of multiple images, and is similar to a multifilm light box. This model is also easy to understand but still not very powerful.

Vendors are now starting to implement what I consider to be a third generation: image areas. Image areas can communicate with other image areas and are basically areas for one or more images to be displayed. The difference from window is that it has intelligent behavior that is based on image type and the fact that it can communicate between itself and other image areas. An example of this would be pulling up a new and old examination in two image areas. Once these have been properly aligned, you should be able to click "next" and have both image areas advance.

In a second-generation IDM, having more monitors is advantageous. It is possible that as third-generation interfaces improve one would want to reduce the number of monitors as the interface makes it more efficient for the computer to move images to the monitor you are focusing on rather than for you to focus your eyes onto a different monitor.

I believe there may be room for a further improvement by the integration of specialized keyboards or keypads that allow a more natural interaction for the common things radiologists need to do such as adjust window level or do "next" and "previous." While it is certainly possible to accomplish this with a mouse or a keystroke, a dedicated keypad would probably be most efficient and most apparent to the novice user.

INFORMATION SYSTEM INTEGRATION

It would be hard to underestimate the importance of integrating image information with textual information such as that stored in a typical radiology information system (RIS). The RIS provides practical information (required by ACR[1]) such as the age and gender of the patient as well as (hopefully) the indication for examination and the referring physician. Perhaps even more crucial is the integration of RIS with PACS to create a worklist. In a production environment it is not feasible for a radiologist to select the next patient from the list of all possible patients on a PACS. Rather, a worklist is the list of all examinations that are to be read, perhaps filtered by some criteria such as the anatomy and/or the modality. After an examination is reported, the radiologist can click a button to get the next examination from the worklist. Without the integration of order information from the RIS and the PACS, a worklist is impossible.

The worklist also allows prediction as to which images are likely to be required on a certain workstation and can potentially reduce the network requirements. The ability to rapidly bring up the next case has a significant impact on the productivity of the radiologist. A system-wide worklist allows gains in system-wide efficiency of the radiology department. For example, if one radiologist has their personal worklist, a global worklist allows them to read images located anywhere at the time that is most convenient. Other advantages of system integration is that as soon as a radiologic examination is ordered, the RIS can instruct the PACS to retrieve any previous examinations allowing maximum opportunity for comparison with prior examinations (prefetching).

CONCLUSION

A successful PACS implementation requires well-designed hardware, a thoughtful software implementation, and a high degree of integration of PACS and RIS information. Although it may be difficult to avoid some of the technical jargon, perhaps the most important evaluation step is to sit at a workstation and see if the image display metaphor is one that can conform to your image interpretation style. Finally, integration of RIS and PACS is crucial.

REFERENCE

1. American College of Radiology. Standards 1996. Reston, VA, ACR, 1996, pp 57-59